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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/735,192	12/12/2003	Jae-Geol Cho	5000-1-501	2611

7590 09/22/2006

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EXAMINER	
MCPHERSON, JOHN A	

ART UNIT	PAPER NUMBER
1756	

DATE MAILED: 09/22/2006

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	10/735,192	CHO ET AL.	
	Examiner	Art Unit	
	John A. McPherson	1756	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *12 December 2003*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-20* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☒ Claim(s) *11-18* is/are allowed.

6)☒ Claim(s) *1-10,19 and 20* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *12 December 2003* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☒ All b)☐ Some * c)☐ None of:

1.☒ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Claim Rejections - 35 USC § 112

1. The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

Claims 19 and 20 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

Claims 19 is indefinite because the elements which comprise the claimed microlens, and their positions relative to each other, are unclear. Specifically, claim 19 is drawn to a microlens comprising a thin film material on a substrate, a photoresist pattern, a thin-film structure formed by etching the thin film, and a lens comprising the thin film structure reflowed. However, it is not clear how the microlens can comprise the thin film if the thin film has been etched to convert it into a thin film structure, and it is not clear how the microlens can comprise the thin-film structure if the thin-film structure has been reflowed to convert it into a lens. Additionally, the location of the photoresist relative to the lens is unclear.

Base upon a comparison to the method of claim 1, it appears that claim 19 is not drawn to the microlens only, but to a combination of each intermediate structure produced at the end of every step of the method, in addition to the finally produced microlens.

Similarly, claim 20 is indefinite because the elements which comprise the claimed optical module, and their positions relative to each other, are unclear. Likewise, claim

20 appears to comprise a combination of each intermediate structure produced at the end of every method step of claim 11, in addition to finally produced optical module.

Claim Rejections - 35 USC § 102

2. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

Claims 1-10 and 19 are rejected under 35 U.S.C. 102(b) as being anticipated by JP 6-326285 (JP '285). JP '285 discloses a method for manufacturing microlenses comprising the steps of forming a doped silicate glass film on a silicon substrate having a silicon oxide film thereon, the doped silicate glass comprising boro phospho silicate glass with about 6% phosphorus and about 4% boron; masking the doped silicate glass film with a photoresist; using the photoresist as a mask to etch the doped silicate glass film; and reflowing the doped silicate glass film, for example at 900 C for 30 minutes, to form a group of microlenses. See the abstract; paragraphs [0013] to [0020] of the computer-generated translation; and Figures 1-9.

3. Claims 1, 2, 5-10 and 19 are rejected under 35 U.S.C. 102(b) as being anticipated by US 5,846,694 to Strand et al. (Strand). Strand discloses a method for fabricating a spherical ball lens comprising the steps of depositing a doped silica material on a substrate, depositing and patterning a resist material to form pattern

masks, etching the doped silica material to form precursors, and applying heat to reflow the precursors to form near-circular cross sectional lenses. See the abstract; column 5, lines 13-29; and Figures 5A-H.

Claim Rejections - 35 USC § 103

4. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claims 1-10 and 19 are rejected under 35 U.S.C. 103(a) as being unpatentable over US 5,064,266 to Sun et al. (Sun) in view of US 5,846,694 to Strand et al. (Strand). Sun discloses a method of forming circular channel waveguides and lenses comprising the steps of patterning a long rectangular waveguide and a short block waveguide on a substrate, the waveguides comprising a cladding layer and core layer, the core layer comprising SiO_2 and one or more dopents such as GeO_2, B_2O_3 and P_2O_5; and heating the waveguides to simultaneously form the channel waveguides and monolithic lenses having circular cross section shapes. See the abstract; column 3, lines 17-58; column 4, lines 28-39; column 5, lines 22 to 66; and Figures 3A, 3B, 4A, 4B and 5. However, Sun does not teach patterning the waveguides by forming a photoresist pattern, and etching the structure using the photoresist pattern.

Strand discloses method for patterning a waveguide material comprising the steps of depositing a resist material on a waveguide material, removing unwanted

excess resist material to form a pattern mask, and etching the waveguide material. See the abstract and column 56-61. It would have been obvious to one skilled in the requisite art to utilize a resist material and an etching step, as taught by Strand, to pattern the waveguides in the process of Sun because it is taught that etching through a pattern mask formed from a resist is an art-recognized method for patterning waveguide materials.

Allowable Subject Matter

5. Claims 11-18 are allowed because in a method of fabricating an optical module having a micro-lens integrated therein as set forth in claim 11, the prior art does not teach or suggest the step (d) of forming a thin-film structure in a lens forming area by selectively removing the upper cladding layer in an area other that the area of the PLC and the lens forming area, nor does the prior art teach or suggest an optical module having such a structure.

6. Any inquiry concerning this communication or earlier communications from the examiner should be directed to John A. McPherson whose telephone number is (571) 272-1386. The examiner can normally be reached on Monday through Friday, 8:00 AM to 4:30 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Mark Huff can be reached on (571) 272-1385. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

John A. McPherson
Primary Examiner
Art Unit 1756

JAM
9/11/06

Notice of References Cited	Application/Control No. 10/735,192	Applicant(s)/Patent Under Reexamination CHO ET AL.	
	Examiner John A. McPherson	Art Unit 1756	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-5,846,694	12-1998	Strand et al.	430/321
*	B	US-5,064,266	11-1991	Sun et al.	385/132
	C	US-			
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N	JP 6-326285 A	11-1994	Japan	Jitsuzawa et al.	---
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

PAT-NO: JP406326285A

DOCUMENT-IDENTIFIER: JP 06326285 A

TITLE: MANUFACTURE OF **MICROLENS**

PUBN-DATE: November 25, 1994

INVENTOR-INFORMATION:
NAME
JITSUZAWA, YOSHISUE
AOE, HIROYUKI

ASSIGNEE-INFORMATION:
NAME COUNTRY
SANYO ELECTRIC CO LTD N/A

APPL-NO: JP05114888

APPL-DATE: May 17, 1993

INT-CL (IPC): H01L027/14, G02B003/00

ABSTRACT:

PURPOSE: To obtain a high performance **microlens** excellent in productivity, by forming s doped silicate glass film on an isomeric base film whose softening temperature is higher than a silicate glass film, and **reflowing** the glass film.

CONSTITUTION: Each element of a solid state image sensor is formed on a silicon substrate 1. A silicon oxide film 2 is formed on the surface of the silicon substarte 1, so as to cover each of the elements. A BPSG film 3 is formed to be, e.g. 800nm thick on the silicon oxide film 2. As to the composition of the BPSG film 3, about 6wt.% of phosphorus and 4wt.% of boron are desirable in order to obtain the softening temperature of about 900°C. The part where **microlenses** are to be formed on the BPSG film 3 surface is masked with **photoresist** 4, and the BPSG film 3 is anisotropically **etched** until the base silicon oxide film 2 is exposed. The anisotropically **etched** BPSG film 3 is subjected to glass **reflow** and softened. Thereby a semi-spherical **microlens** group can be formed.

DERWENT-ACC-NO: 1995-046951

DERWENT-WEEK: 199507

TITLE: Mfg. micro lens - involves etching BPSG film after masking with photoresist and performing glass reflow to form lens

PATENT-ASSIGNEE: SANYO ELECTRIC CO LTD[SAOL]

PRIORITY-DATA: 1993JP-0114888 (May 17, 1993)

PATENT-FAMILY:

PUB-NO	PUB-DATE	LANGUAGE	PAGES	MAIN-IPC
JP 06326285 A	November 25, 1994	N/A	006	H01L 027/14

APPLICATION-DATA:

PUB-NO	APPL-DESCRIPTOR	APPL-NO	APPL-DATE
JP 06326285A	N/A	1993JP-0114888	May 17, 1993

INT-CL (IPC): G02B003/00, H01L027/14

ABSTRACTED-PUB-NO: JP 06326285A

BASIC-ABSTRACT:

The mfr. of a micro lens involves forming a silicon oxide film (2) on the surface of a silicon substrate (1) on which a solid state image pick up element is formed. A BPSG film (3) is formed above the silicon oxide film. The portion of the BPSG film which forms the micro lens is masked by a photoresist. Then anisotropic etching of the BPSG film is carried out until the silicon oxide film is exposed. Then a glass reflow is performed and the pillar like BPSG film is made into hemispherical lens.

ADVANTAGE - Increased productivity and reduced cost.

CHOSEN-DRAWING: Dwg.1/17

TITLE-TERMS: MANUFACTURE MICRO LENS ETCH BPSG FILM AFTER MASK PHOTORESIST PERFORMANCE GLASS REFLOW FORM LENS

ADDL-INDEXING-TERMS:
BORO PHOSPHO BOROSILICATE GLASS

DERWENT-CLASS: L03 P81 U11

CPI-CODES: L04-C06A; L04-C12A; L04-C12D;

EPI-CODES: U11-C18D;

SECONDARY-ACC-NO:
CPI Secondary Accession Numbers: C1995-021108
Non-CPI Secondary Accession Numbers: N1995-037168

(19)日本国特許庁（ＪＰ）　(12)**公開特許公報**（A）　(11)特許出願公開番号

特開平6－326285

(43)公開日　平成６年(1994)11月25日

(51)Int.Cl.[5]	識別記号	庁内整理番号	ＦＩ	技術表示箇所
Ｈ０１Ｌ　27/14				
Ｇ０２Ｂ　3/00		A　8106－2K		
		7210－4M	Ｈ０１Ｌ　27/ 14	D

審査請求　未請求　請求項の数１　ＯＬ　（全 6 頁）

(21)出願番号　特願平5－114888

(22)出願日　平成５年(1993) 5月17日

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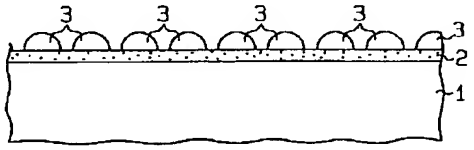
(74)代理人　弁理士　恩田　博宣

(54)【発明の名称】　マイクロレンズの製造方法

(57)【要約】
【目的】生産性に優れ高性能なマイクロレンズを製造する。
【構成】シリコン基板１上に固体撮像素子の各素子（図示略）を形成する。そして、当該半導体素子を覆うようにシリコン基板１の表面にシリコン酸化膜２を形成する。続いて、シリコン酸化膜２の上にＢＰＳＧ膜３を適宜な厚さ（例えば８００nm）だけ形成する。一般的なフォトリソグラフィーを用い、ＢＰＳＧ膜３の表面のマイクロレンズを形成したい部分をフォトレジスト４でマスキングする。フォトレジスト４をマスクとして、下地のシリコン酸化膜２が露出するまでＢＰＳＧ膜３を異方性エッチングする。異方性エッチングしたＢＰＳＧ膜３にガラスリフローを行って軟化させる。すると、円柱状のＢＰＳＧ膜３が、表面張力によって半球状のレンズ形状に変形する。



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【特許請求の範囲】

【請求項１】　不純物を添加した適宜な膜厚のシリケートガラス膜（３）を、当該シリケートガラス膜（３）より軟化温度が高い下地異種膜（２）上に形成する工程と、当該シリケートガラス膜（３）にガラスリフローを行う工程とを備えたことを特徴とするマイクロレンズの製造方法。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明はマイクロレンズの製造方法に関するものである。

【０００２】

【従来の技術】近年、固体撮像素子などの半導体光ディバイスにマイクロレンズを設けることが考えられており、そのようなマイクロレンズの製造方法について種々の提案がなされている。しかしながら、従来提案されている方法は、具体的に実施するのが困難であるばかりでなく、歩留りが悪いものばかりであった。

【０００３】例えば、特開平３－１６９０７６号公報（国際特許分類　Ｈ０１Ｌ　２７／１４）では、フォトレジストパターンを所定の温度（１００～１５０°Ｃ／数十分）で熱処理することにより、流動させてマイクロレンズを形成している。

【０００４】しかしながら、この方法では、レンズ自体がフォトレジストによって形成されているため、①物理的な強度が低い、②接着性が悪い、③一般に用いられるフォトレジストは有色（黄色または赤色）であるため可視光域では使えない、④比較的低温で形成可能であるという利点を裏返せば、そのまま耐熱性の悪さ（変形や変色）や耐久性の低さという欠点につながる、などの問題があった。

【０００５】また、特公平５－１２８６４号公報（国際特許分類　Ｈ０１Ｌ　２７／１４，Ｇ０２Ｂ　６／４２）では、以下の方法によってマイクロレンズを形成している。まず、アクリル系樹脂（ポリグリシジルメタクリレートやポリメチルメタクリレートなど）の上に、前記特開平３－１６９０７６号公報と同様にしてフォトレジストによるマイクロレンズを形成する。その後、エッチバックによって、フォトレジストに形成したレンス形状をアクリル系樹脂に転写し、アクリル系樹脂によるマイクロレンズを形成する。

【０００６】しかしながら、この方法では、①製造プロセスが複雑である、②フォトレジストとアクリル系樹脂のエッチ速度が同一であったとしても、フォトレジストに形成したレンズ形状をアクリル系樹脂に正確に転写するためのプロセス制御がシビアで極めて難しい、などの問題があった。

【０００７】

【発明が解決しようとする課題】本発明は上記問題点を解決するためになされたものであって、その目的は、生

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産性に優れ（具体的には、製造プロセスの容易さ、高い歩留り、低いコスト、等）、高性能（具体的には、物理的な強度の高さ、良好な接着性、無色で高透明度、高い耐熱性および耐久性、等）なマイクロレンズの製造方法を提供することにある。

【０００８】

【課題を解決するための手段】本発明は、不純物を添加した適宜な膜厚のシリケートガラス膜を、当該シリケートガラス膜より軟化温度が高い下地異種膜上に形成する工程と、当該シリケートガラス膜にガラスリフローを行う工程とを備えたことをその要旨とする。

【０００９】

【作用】不純物を添加したシリケートガラス膜は、当該シリケートガラス膜より軟化温度が高い下地異種膜上に形成した後にガラスリフローを行うと、軟化して流動可能になる。そのとき、表面張力によって、下地異種膜とシリケートガラス膜との境界の幅がほとんど変化しない状態で、軟化したシリケートガラス膜は断面円弧状になる。このように形成された断面円弧状のシリケートガラス膜はレンズとしての集光能力をもっている。

【００１０】ここで、添加する不純物を適宜に選択しさえすれば、当該シリケートガラス膜に、物理的な強度，透明度，耐熱性および耐久性がいずれも高く、接着性が良好で無色であるという性質をもたせることができる。そのため、当該シリケートガラス膜によって形成されたマイクロレンズにもこの性質は受け継がれ、高性能なマイクロレンズを得ることができる。

【００１１】また、不純物を添加したシリケートガラス膜の形成技術およびガラスリフロー技術は、既に確立している上に極く容易かつ簡単なものであり、当該マイクロレンズの製造にあたっては高い歩留りと低いコストとを両立させることができる。

【００１２】さらに、当該マイクロレンズの形状は、当該シリケートガラス膜のパターニング形状とその膜厚とを調整することによって適宜に選択することができる。また、当該シリケートガラス膜の下層に同じ材質のシリケートガラス膜が適宜な膜厚だけ形成されていた場合、当該マイクロレンズの形状は、そのパターニング形状と膜厚との調整に加え、下層のシリケートガラス膜の膜厚を調整することによって適宜に選択することができる。

【００１３】

【実施例】以下、本発明を具体化した一実施例のマイクロレンズの製造プロセスを、図１～図４に示す断面図に従って説明する。尚、本実施例では、半導体光ディバイスの代表的なものである固体撮像素子の画素毎に集光のためのマイクロレンズを形成する場合を示しており、形成されるのは、半球状のマイクロレンズ群である。

【００１４】プロセス１（図１参照）；シリコン基板１上に固体撮像素子の各素子（図示略）を形成する。そして、当該半導体素子を覆うようにシリコン基板１の表面

にシリコン酸化膜２を形成する。ここで、シリコン酸化膜２の形成方法はどのようなものでもよい（例えば、熱酸化、ＣＶＤ法、ＰＶＤ法、等）。続いて、シリコン酸化膜２の上にＢＰＳＧ（Boro Phospho Silicate Glass）膜３を適宜な厚さ（例えば８００nm）だけ形成する。ここで、ＢＰＳＧ膜３の形成方法はどのようなものでもよい（例えば、低圧または常圧ＣＶＤ法、それらＣＶＤ法とプラズマ法との併用、スパッタリング、粉末ガラス法〔Sedimentation 法〕、等）。尚、ＢＰＳＧ膜３の組成は、リン濃度：約６重量％、ボロン濃度：約４重１％、程度が実用上好ましい。この組成で形成すれば、後記するように、ＢＰＳＧ膜３の軟化温度は９００°Ｃ程度になる。リン濃度およびボロン濃度をこれより高くするとＢＰＳＧ膜３の軟化温度が下がる。但し、形成方法にもよるが、リン濃度およびボロン濃度をあまり高くするとＢＰＳＧ膜３に不要な析出物が生じることになる。

【００１５】プロセス２（図２参照）；一般的なフォトリソグラフィーを用い、ＢＰＳＧ膜３の表面のマイクロレンズを形成したい部分をフォトレジスト４でマスキングする。

【００１６】プロセス３（図３参照）；フォトレジスト４をマスクとして、下地のシリコン酸化膜２が露出するまでＢＰＳＧ膜３を異方性エッチングする。ここで、異方性エッチングはどのような方法によって行ってもよい（例えば、反応性イオンエッチング、イオンミシリング、反応性イオンミシリング、等）。

【００１７】プロセス４（図４参照）；異方性エッチングしたＢＰＳＧ膜３にガラスリフローを行って軟化させる。ここで、ガラスリフローは、ＢＰＳＧ膜３が軟化しさえすればどのような条件であってもよい（例えば、プロセス１で例示した組成〔リン濃度：約６重量％、ボロン濃度：約４重量％〕で膜厚〔８００nm〕のＢＰＳＧ膜３の場合は、９００°Ｃの酸素雰囲気中で３０分間）。すると、円柱状のＢＰＳＧ膜３が、表面張力によって半球状のレンズ形状に変形する。

【００１８】このように、本実施例においては、シリコン酸化膜２上にＢＰＳＧ膜３を形成し、そのＢＰＳＧ膜３をパターニングした後にガラスリフローを行うことによって、半球状のマイクロレンズ群を形成することができる。

【００１９】ところで、マイクロレンズの形状を変化させて所望の焦点距離を得るには、ＢＰＳＧ膜３のパターン幅と膜厚とを適宜に変更すればよい。図５（ａ）は、パターニングした膜厚：８００nmのＢＰＳＧ膜３における、ライン・アンド・スペース（以下、Ｌ／Ｓとする）とリフロー角θとの関係を示すグラフである。ＢＰＳＧ膜３の膜厚が同じなら、Ｌ／Ｓが大きいほどリフロー角θは小さくなる。尚、ここで、Ｌ／Ｓとリフロー角θとの関係を調べたのは、ＢＰＳＧ膜３の断面をとりやすくするためである（半球状のＢＰＳＧ膜３では断面をとりにくい）。

【００２０】これを利用すれば、マイクロレンズの形状を任意に変化させて所望の焦点距離を得ることができる。図６～図９は、それを模式的に示した断面図である。図６に示すようにパターニングしたＢＰＳＧ膜３（膜厚：Ｔ、Ｌ／Ｓ：ｒ）にガラスリフローを行って得られたレンズ形状を図７に示す。同じく、図８に示すようにパターニングしたＢＰＳＧ膜３（膜厚：Ｔ、Ｌ／Ｓ：Ｒ、但しＲ＞ｒ）にガラスリフローを行って得られたレンズ形状を図９に示す。シリコン酸化膜２上に形成したＢＰＳＧ膜３にガラスリフローを行うと、シリコン酸化膜２とＢＰＳＧ膜３とが接する部分の境界の幅（すなわち、パターンの底の幅）がほとんど変化せずに、ほぼ完全な断面円弧状のレンズ形状を形成することができる。ここで、ＢＰＳＧ膜３の膜厚：Ｔを同じにしてＬ／Ｓを変えると、図７および図９に示すように、膜厚とＬ／Ｓとの比（Ｔ／ｒ、Ｔ／Ｒ）によって焦点距離の異なるマイクロレンズが形成されることになる。すなわち、図７に示すように、膜厚とＬ／Ｓとの比（Ｔ／ｒ）が大きい場合は、厚いレンズが形成され焦点距離は短くなる。一方、図９に示すように、膜厚とＬ／Ｓとの比（Ｔ／Ｒ）が小さい場合は、薄いレンズが形成され焦点距離は長くなる。

【００２１】ところで、上記プロセス３において、ＢＰＳＧ膜３を異方性エッチングする際に、下地のシリコン酸化膜２が露出するまでエッチングせずＢＰＳＧ膜３を残存させた場合、残存させたＢＰＳＧ膜３の膜厚およびＬ／Ｓによっては、レンズ形状が形成されないことがある。

【００２２】図６（ｂ）は、パターニングした膜厚：８００nmのＢＰＳＧ膜３において、ＢＰＳＧ膜３を２００nmだけ残存させ場合のＬ／Ｓとリフロー角θとの関係を示すグラフである。この例では、ある程度（１．５μm）以上のＬ／Ｓでは、Ｌ／Ｓに関係なくリフロー角θが一定（３０deg.）になっている。図１０～図１３は、その様子を示した断面図である。図１０に示すように、シリコン酸化膜２が露出するまでＢＰＳＧ膜３を異方性エッチングした場合は、上記したように、図１２に示すようなレンズ形状が形成される。一方、図１１に示すように、ＢＰＳＧ膜３を膜厚ｔだけ残存させた場合は、図１３に示すように、流動化したＢＰＳＧ膜３が隣接するライン（パターン）と融合してしまい、レンズ形状にならずに平坦な形状や弱いうねりをもった形状になる。

【００２３】しかしながら、残存させるＢＰＳＧ膜３の膜厚ｔを適宜に調整することによって、レンズ形状を得ることもできる。例えば、パターニングした膜厚：８００nmのＢＰＳＧ膜３においては、膜厚ｔ≦５０nmとすることによってレンズ形状が得られる。これを逆利用すれば、図１４に示すように、パターニングしたＢＰＳＧ膜

3（膜厚：Ｔ１、Ｌ／Ｓ：ｒ１）の膜厚とＬ／Ｓとの比（Ｔ１／ｒ１）が大き過ぎる場合でも適切なレンズ形状を得ることができる。すなわち、膜厚とＬ／Ｓとの比（Ｔ１／ｒ１）が大き過ぎる場合に、下地のシリコン酸化膜２が露出するまでエッチングすると、図１５に示すように、リフロー角θが９０deg.を越えるオーバーハングが生じる。このとき、図１６に示すように、残存させるＢＰＳＧ膜３の膜厚ｔを適宜に調整することにより、流動化したＢＰＳＧ膜３が隣接するライン（パターン）と融合してオーバーハングが適当に調整され、図１７に示すように、適切なレンズ形状を得ることができる。

【００２４】このように、上記各実施例においては、ＢＰＳＧ膜にガラスリフローを行うことによってＢＰＳＧ膜を軟化させ、表面張力によって半球状のマイクロレンズを形成することができる。ＢＰＳＧ膜は、物理的な強度，透明度，耐熱性および耐久性がいずれも高く、接着性が良好で無色であるという性質を有している。そのため、ＢＰＳＧ膜によって形成されたマイクロレンズにもこの性質は受け継がれ、高性能なマイクロレンズを得ることができる。また、ＢＰＳＧ膜の形成技術およびガラスリフロー技術は、既に確立している上に極く容易かつ簡単なものであり、当該マイクロレンズの製造にあたっては高い歩留りと低いコストとを両立させることができる。

【００２５】ちなみに、本発明は上記実施例に限定されるのではなく、以下のように実施してもよい。

１）ＢＰＳＧ膜３の下地のシリコン酸化膜２を、ＢＰＳＧ膜３より軟化温度が高い他の膜（例えば、ポリシリコン膜、シリコン窒化膜、アルミナ膜、ＰＳＧ〔Phospho-Silicate Glass〕膜、等）に置き換える。この場合も、上記と同様の作用によってマイクロレンズを形成することができる。

【００２６】２）ＢＰＳＧ膜３を、他の不純物を添加したシリケートガラス膜（例えば、ＰＳＧ膜、ＢＳＧ〔Boro Silicate Glass〕膜、ＡＳＧ〔Alumino Silicate Glass〕膜、その他、Ｈ素を含むシリケートガラス膜など）に置き換える。この場合も、上記と同様の作用によってマイクロレンズを形成することができる。また、下地のシリコン酸化膜２を、そのＢＰＳＧ膜３に置き換えた膜より軟化温度が高い膜に置き換えることができる。

【００２７】３）ＢＰＳＧ膜３により半球状のマイクロレンズを形成するのではなく、適宜な形状（例えば、櫛歯状に並んだ蒲鉾状）のマイクロレンズを形成する。

【００２８】

【発明の効果】以上詳述したように本発明によれば、生

産性に優れ（具体的には、製造プロセスの容易さ、高い歩留り、低いコスト、等）、高性能（具体的には、物理的な強度の高さ、良好な接着性、無色で高透明度、高い耐熱性および耐久性、等）なマイクロレンズを製造することができるという優れた効果がある。

【図面の簡単な説明】

【図１】本発明を具体化した一実施例のマイクロレンズの製造プロセスを示す断面図である。

【図２】本発明を具体化した一実施例のマイクロレンズの製造プロセスを示す断面図である。

【図３】本発明を具体化した一実施例のマイクロレンズの製造プロセスを示す断面図である。

【図４】本発明を具体化した一実施例のマイクロレンズの製造プロセスを示す断面図である。

【図５】パターニングしたＢＰＳＧ膜における、ライン・アンド・スペース（Ｌ／Ｓ）とリフロー角θとの関係を示すグラフである。

【図６】本発明を具体化した別の実施例を説明するための断面図である。

【図７】本発明を具体化した別の実施例を説明するための断面図である。

【図８】本発明を具体化した別の実施例を説明するための断面図である。

【図９】本発明を具体化した別の実施例を説明するための断面図である。

【図１０】本発明を具体化した別の実施例を説明するための断面図である。

【図１１】本発明を具体化した別の実施例を説明するための断面図である。

【図１２】本発明を具体化した別の実施例を説明するための断面図である。

【図１３】本発明を具体化した別の実施例を説明するための断面図である。

【図１４】本発明を具体化した別の実施例を説明するための断面図である。

【図１５】本発明を具体化した別の実施例を説明するための断面図である。

【図１６】本発明を具体化した別の実施例を説明するための断面図である。

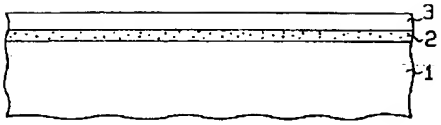
【図１７】本発明を具体化した別の実施例を説明するための断面図である。

【符号の説明】

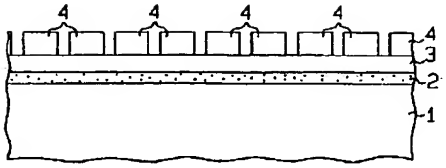
２　下地異種膜としてのシリコン酸化膜

３　不純物を添加したシリケートガラス膜としてのＢＰＳＧ膜

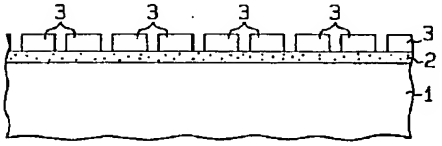
【図1】



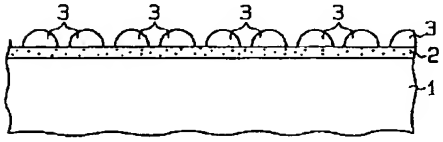
【図2】



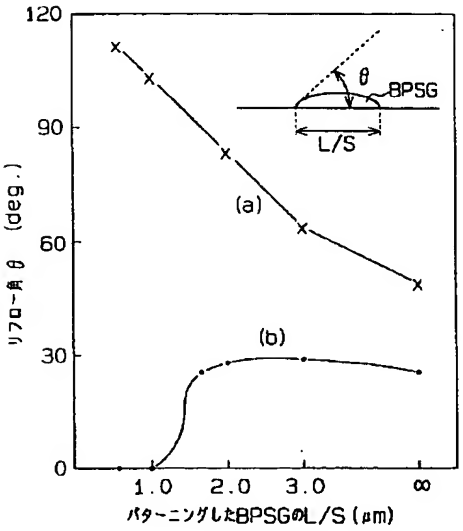
【図3】



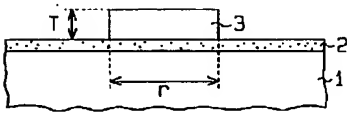
【図4】



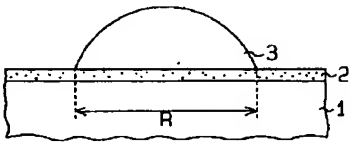
【図5】



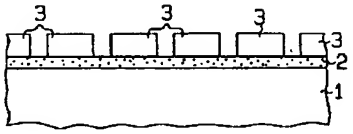
【図6】



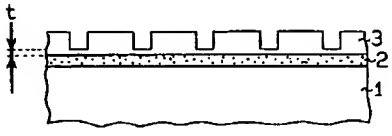
【図9】



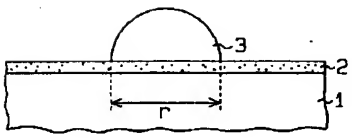
【図10】



【図11】



【図7】



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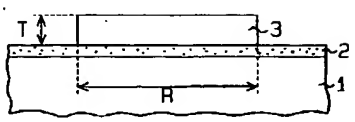
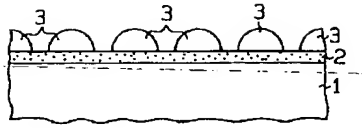
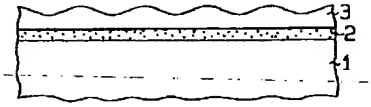


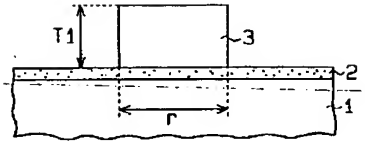
【図12】



【図13】



【図14】



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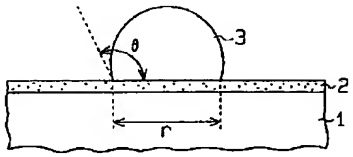
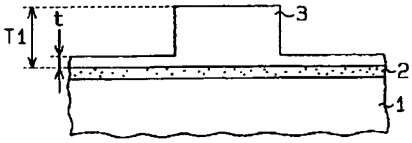
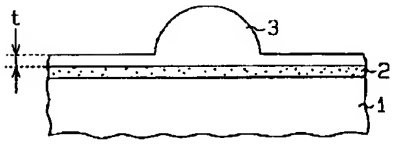


【図16】



【図17】



FULL CONTENTS

[Claim(s)]

[Claim 1] The manufacture method of the micro lens characterized by having the process which forms the proper silicate glass film (3) of thickness which added the impurity on a ground different-species film (2) with high softening temperature from the silicate glass film (3) concerned, and the process which performs a glass reflow on the silicate glass film (3) concerned.

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention relates to the manufacture method of a micro lens.

[0002]

[Description of the Prior Art] It is possible to semiconductor light devices, such as a solid state image pickup device, to prepare a micro lens, and various proposals are made about the manufacture method of such a micro lens in recent years. However, the method by which the conventional proposal is made had it being not only difficult to carry out concretely but a bad yield.

[0003] For example, in JP,H3-169076,A (International Patent Classification H01L 27/14), by heat-treating a photoresist pattern at a predetermined temperature (100-150 degreeC / tens of minutes), it is made to flow and the micro lens is formed.

[0004] However, since the lens itself is formed of photoresist by this method, ** ** with bad ** adhesive property with physical low hardness -- ** which cannot be used in a light region since the photoresist generally used is colored (yellow or red) -- if the advantage that it can comparatively form at low temperature is turned over There were problems, such as being then connected with the fault of heat-resistant badness (modification and discoloration) or

durable lowness.

[0005] Moreover, in JP,H5-12864,B (International Patent Classification H01L 27/14, G02B 6/42), the micro lens is formed by the following methods. First, the micro lens by photoresist is formed like said JP,H3-169076,A on acrylic resin (polyglycidylmethacrylate, polymethylmethacrylate, etc.). Then, the Lons form formed in photoresist is transferred to acrylic resin with etchback, and the micro lens by acrylic resin is formed.

[0006] However, [this method] even if the dirty velocity of ** photoresist and acrylic resin with complicated ** manufacture process is the same There were problems, like the process control for transferring correctly the lens form formed in photoresist to acrylic resin is severe, and very difficult.

[0007]

[Problem to be solved by the invention] Are made in order that this invention may solve the above-mentioned problem, and [the purpose] excellent (specifically the ease of a manufacture process, high yield, low cost, etc.) in productivity -- high performance (specifically, they are high transparency, a high heat-resisting property, endurance, etc. at the height of physical hardness, a good adhesive property, and colorlessness) -- it is in offering the manufacture method of a micro lens.

[0008]

[Means for solving problem] This invention carries out having had the process which forms the proper silicate glass film of thickness which added the impurity on the ground different-species film whose softening temperature is higher than the silicate glass film concerned, and the process which performs a glass reflow on the silicate glass film concerned with the summary.

[0009]

[Function] If the silicate glass film which added the impurity performs a glass reflow after forming it on the ground different-species film whose softening temperature is higher than the silicate glass film concerned, it will soften and a flow of it will be attained. The silicate glass film which the width of the limits of a ground different-species film and a silicate glass film softened in the state where it hardly changes, with surface tension becomes an arc shaped cross section then. Thus, the formed arc shaped cross section silicate glass film has the condensing capability as a lens.

[0010] Here, if only it chooses the impurity to add suitably, the character in which each of physical hardness, transparency, heat-resisting properties, and endurance is high, and an adhesive property is good and colorlessness can be given to the silicate glass film concerned. Therefore, this character is inherited by the micro lens formed with the silicate glass film concerned, and a highly efficient micro lens can be obtained.

[0011] when [moreover,] having already established the formation technology and glass reflow technology of a silicate glass film which added the impurity -- **** -- the high yield and

low cost can be reconciled [in / it is easy and easy and / manufacture of the micro lens concerned].

[0012] Furthermore, the form of the micro lens concerned can be suitably chosen by adjusting the patterning form and thickness of the silicate glass film concerned. Moreover, when only thickness with a proper silicate glass film of the same quality of the material as the lower layer of the silicate glass film concerned is formed, [the form of the micro lens concerned] In addition to adjustment with the patterning form and thickness, it can choose suitably by adjusting the thickness of a lower layer silicate glass film.

[0013]

[Working example] The manufacture process of the micro lens of one example which materialized this invention is hereafter explained according to the sectional view shown in drawing 1 - drawing 4 . In addition, at this example, the case where the micro lens for condensing is formed is shown for every pixel of the typical solid state image pickup device of a semiconductor light device, and a hemispherical micro lens group is formed in it.

[0014] Process 1 (refer to drawing 1); each element (illustration abbreviation) of a solid state image pickup device is formed on the silicon substrate 1. And silicon oxide 2 is formed in the surface of the silicon substrate 1 so that the semiconductor device concerned may be covered. Here, what kind of thing is sufficient as the formation method of silicon oxide 2 (for example, thermal oxidation, a CVD method, PVD, etc.)? Then, only proper thickness (for example, 800nm) forms the BPSG (Boro Phospho Silicate Glass) film 3 on silicon oxide 2. Here, what kind of thing is sufficient as the formation method of BPSG film 3 (for example, concomitant use with low pressure or an ordinary pressure CVD method, these CVD methods, and the plasma method, sputtering, and granulated glass method [Sedimentation method] etc.)? in addition, the presentation of BPSG film 3 -- phosphorus concentration: -- about 6 weight % and boron concentration: -- about 4-fold 1% and a grade are desirable practically. If it forms by this presentation, the softening temperature of BPSG film 3 will turn into a 900 degreeC grade so that a postscript may be carried out. If phosphorus concentration and boron concentration are made higher than this, the softening temperature of BPSG film 3 will fall. However, although based also on the formation method, when phosphorus concentration and boron concentration are made not much high, an unnecessary deposit will arise in BPSG film 3.

[0015] Process 2 (refer to drawing 2); a portion to form the micro lens of the surface of BPSG film 3 in is masked by photoresist 4 using general photo lithography.

[0016] Process 3 (refer to drawing 3); by using photoresist 4 as a mask, anisotropic etching of BPSG film 3 is carried out until the silicon oxide 2 of a ground is exposed. Here, you may perform anisotropic etching by what kind of method (for example, reactant ion etching, IOMMI Schiling, reactant IOMMI Schiling, etc.).

[0017] Process 4 (refer to drawing 4); a glass reflow is performed to BPSG film 3 which

carried out anisotropic etching, and it is softened. Here, glass reflow may be what kind of conditions, if only BPSG film 3 becomes soft (in the case [About 6 weight %, boron concentration: For example, presentation [phosphorus concentration illustrated in the process 1 : about 4 weight %]] of BPSG film 3 of thickness [800nm] inside of the oxygen environment of ** and 900 degreeC for 30 minutes). Then, cylindrical BPSG film 3 changes into hemispherical lens form with surface tension.

[0018] Thus, in this example, after forming BPSG film 3 on silicon oxide 2 and patterning the BPSG film 3, a hemispherical micro lens group can be formed by performing a glass reflow.

[0019] By the way, what is necessary is just to change the pattern width and thickness of BPSG film 3 suitably, in order to change the form of a micro lens and to obtain a desired focal distance. Thickness which drawing 5 (a) patterned: It is the graph in which the relation of the line and space (it is hereafter considered as L/S) and the reflow angle theta in 800nm BPSG film 3 is shown. If the thickness of BPSG film 3 is the same, the reflow angle theta becomes small, so that L/S is large. In addition, the relation between L/S and the reflow angle theta was investigated here in order to make the section of BPSG film 3 easy to take (in hemispherical BPSG film 3, it is hard to take a section).

[0020] If this is used, the form of a micro lens can be changed arbitrarily and a desired focal distance can be obtained. Drawing 6 - drawing 9 are the sectional views having shown it typically. The lens form acquired by performing a glass reflow to BPSG film 3 (thickness: T, L/S:r) patterned as shown in drawing 6 is shown in drawing 7 . The lens form acquired by performing a glass reflow to BPSG film 3 (thickness: T, L/S:R, however R>r) similarly patterned as shown in drawing 8 is shown in drawing 9 . If a glass reflow is performed to BPSG film 3 formed on silicon oxide 2, the width (namely, width of the bottom of a pattern) of the limits of a portion where silicon oxide 2 and BPSG film 3 touch can form arc shaped cross section nearly perfect lens form, without hardly changing. Here, when thickness:T of BPSG film 3 is made the same and L/S is changed, as shown in drawing 7 and drawing 9 , the micro lens with which focal distances differ will be formed of the ratio (T/r, T/R) of thickness and L/S. That is, as shown in drawing 7 , when the ratio (T/r) of thickness and L/S is large, a thick lens is formed and a focal distance becomes short. On the other hand, as shown in drawing 9 , when the ratio (T/R) of thickness and L/S is small, a thin lens is formed and a focal distance becomes long.

[0021] By the way, in the above-mentioned process 3, when it does not etch until the silicon oxide 2 of the ground was exposed, but carrying out anisotropic etching of BPSG film 3 and BPSG film 3 is made to remain, lens form may not be formed depending on the thickness and L/S of BPSG film 3 which were made to remain.

[0022] Thickness which drawing 6 (b) patterned: In 800nm BPSG film 3, it is the graph in which 200nm of BPSG films 3 are made to remain, and L/S of a case and a relation with the reflow angle theta are shown. In this example, the reflow angle theta is fixed (30deg.) regardless of

L/S to some extent (1.5 micrometers) at the above L/S. Drawing 10 - drawing 13 are the sectional views having shown the situation. When anisotropic etching of BPSG film 3 is carried out until silicon oxide 2 is exposed as shown in drawing 10 , as described above, lens form as shown in drawing 12 is formed. On the other hand, when only thickness t makes BPSG film 3 remain as shown in drawing 11 , as shown in drawing 13 , it unites with the line (pattern) which fluidized BPSG film 3 adjoins, and becomes flat form and form with a weak wave, without becoming lens form.

[0023] However, lens form can also be acquired by adjusting suitably the thickness t of BPSG film 3 made to remain. For example, patterned thickness: In 800nm BPSG film 3, lens form is acquired by considering it as t<=50nm of thickness. If this is reverse-used, as shown in drawing 14 , even when the ratio (T1 / r1) of the thickness of BPSG film 3 (thickness: T1, L/S:r1) and L/S which were patterned is too large, suitable lens form can be acquired. That is, if it etches until the silicon oxide 2 of a ground is exposed when the ratio (T1 / r1) of thickness and L/S is too large, as shown in drawing 15 , the overhang with which the reflow angle theta exceeds 90deg. will arise. By adjusting suitably the thickness t of BPSG film 3 made to remain at this time, as shown in drawing 16 , it unites with the line (pattern) which fluidized BPSG film 3 adjoins, and an overhang is adjusted suitably, and as shown in drawing 17 , suitable lens form can be acquired.

[0024] Thus, in each above-mentioned example, by performing a glass reflow to a BPSG film, a BPSG film is softened and a hemispherical micro lens can be formed with surface tension. It has the character in which each of physical hardness, transparency, heat-resisting properties, and endurance of a BPSG film is high, and an adhesive property is good and colorlessness. Therefore, this character is inherited by the micro lens formed with the BPSG film, and a highly efficient micro lens can be obtained. when [moreover,] having already established the formation technology and glass reflow technology of a BPSG film -- **** -- the high yield and low cost can be reconciled [in / it is easy and easy and / manufacture of the micro lens concerned].

[0025] Incidentally, this invention is not limited to the above-mentioned example, but may be carried out as follows.

1) Transpose the silicon oxide 2 of the ground of BPSG film 3 to other films (for example, a polysilicon film, a silicon nitriding film, an alumina film, a PSG [Phospho-Silicate Glass] film, etc.) whose softening temperature is higher than BPSG film 3. Also in this case, a micro lens can be formed by the same operation as the above.

[0026] 2) Transpose BPSG film 3 to the silicate glass films (for example, a PSG film, a BSG [Boro Silicate Glass] film, an ASG [Alumino Silicate Glass] film, the other silicate glass films containing arsenic, etc.) which added other impurities. Also in this case, a micro lens can be formed by the same operation as the above. Moreover, the silicon oxide 2 of a ground can be

transposed to the film whose softening temperature is higher than the film replaced with the BPSG film 3.

[0027] 3) It forms a proper-shaped (the shape of for example, boiled fish paste located in a line in the shape of ****) micro lens rather than forming a hemispherical micro lens with BPSG film 3.

[0028]

[Effect of the Invention] As explained in full detail above, according to this invention, it excels in productivity. (-- concrete -- the ease of a manufacture process, the high yield, low cost, etc. --) -- high performance (specifically, they are high transparency, a high heat-resisting property, endurance, etc. at the height of physical hardness, a good adhesive property, and colorlessness) -- there is an outstanding effect that a micro lens can be manufactured.

[Brief Description of the Drawings]

[Drawing 1] It is the sectional view showing the manufacture process of the micro lens of one example which materialized this invention.

[Drawing 2] It is the sectional view showing the manufacture process of the micro lens of one example which materialized this invention.

[Drawing 3] It is the sectional view showing the manufacture process of the micro lens of one example which materialized this invention.

[Drawing 4] It is the sectional view showing the manufacture process of the micro lens of one example which materialized this invention.

[Drawing 5] It is the graph in which the relation of the line and space (L/S) and the reflow angle theta in the patterned BPSG film is shown.

[Drawing 6] It is a sectional view for explaining another example which materialized this invention.

[Drawing 7] It is a sectional view for explaining another example which materialized this invention.

[Drawing 8] It is a sectional view for explaining another example which materialized this invention.

[Drawing 9] It is a sectional view for explaining another example which materialized this invention.

[Drawing 10] It is a sectional view for explaining another example which materialized this invention.

[Drawing 11] It is a sectional view for explaining another example which materialized this invention.

[Drawing 12] It is a sectional view for explaining another example which materialized this invention.

[Drawing 13] It is a sectional view for explaining another example which materialized this invention.

[Drawing 14] It is a sectional view for explaining another example which materialized this invention.

[Drawing 15] It is a sectional view for explaining another example which materialized this invention.

[Drawing 16] It is a sectional view for explaining another example which materialized this invention.

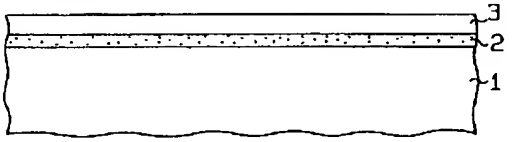
[Drawing 17] It is a sectional view for explaining another example which materialized this invention.

[Explanations of letters or numerals]

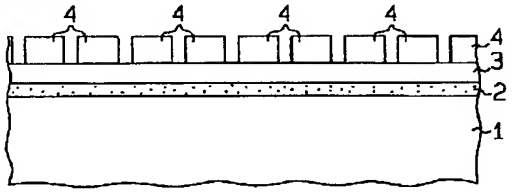
2 Silicon Oxide as a Ground Different-Species Film

3 BPSG Film as a Silicate Glass Film Which Added Impurity

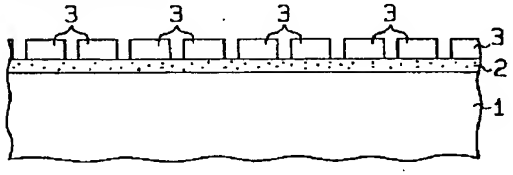
[Drawing 1]



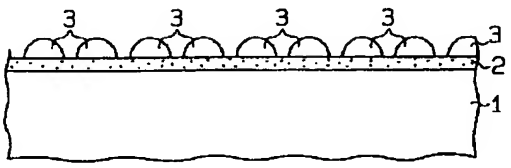
[Drawing 2]



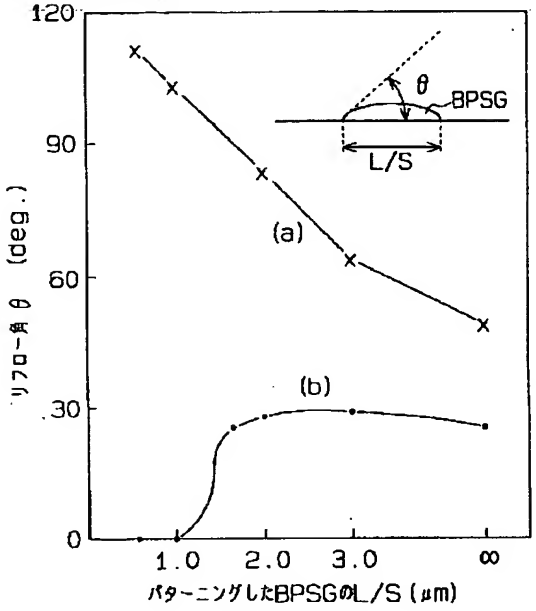
[Drawing 3]



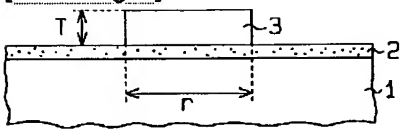
[Drawing 4]



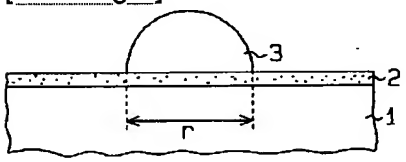
[Drawing 5]



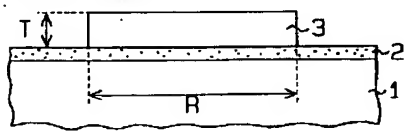
[Drawing 6]



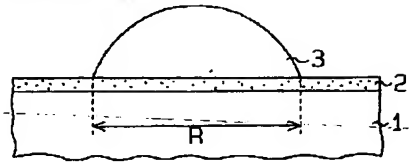
[Drawing 7]



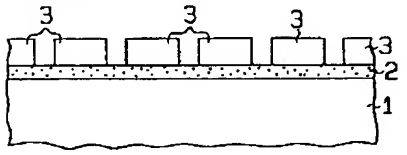
[Drawing 8]



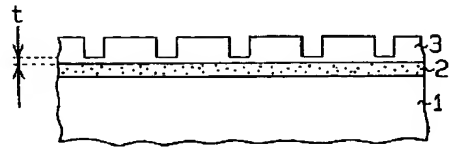
[Drawing 9]



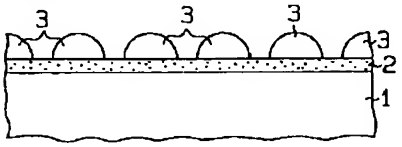
[Drawing 10]



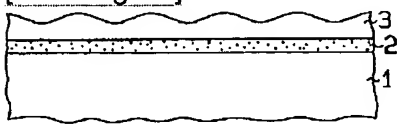
[Drawing 11]



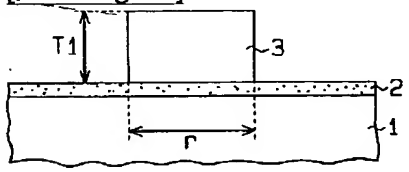
[Drawing 12]



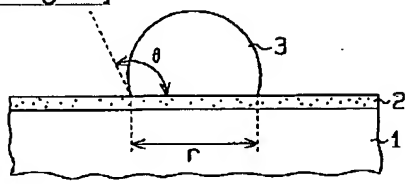
[Drawing 13]



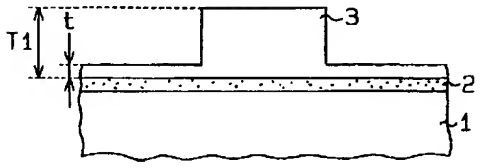
[Drawing 14]



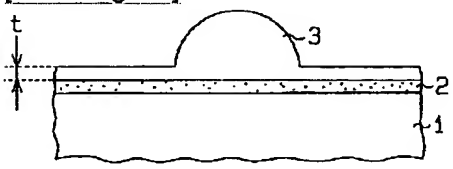
[Drawing 15]



[Drawing 16]



[Drawing 17]



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